UNITED STATES ATOMIC ENERGY COMMISSION

Twentieth Semiannual Report

OF THE

ATOMIC ENERGY COMMISSION

July 1956

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C.

LETTER OF SUBMITTAL

WASHINGTON, D. C.,
31 July 1956.

SIRS: We have the honor to submit herewith the Twentieth Semiannual Report of the United States Atomic Energy Commission, as required by the Atomic Energy Act of 1954.

Respectfully,

UNITED STATES ATOMIC ENERGY COMMISSION,
WILLARD F. LIBBY.
THOMAS E. MURRAY.
HAROLD S. VANCE.
JOHN VON NEUMANN.
LEWIS L. STRAUSS, *Chairman*

The Honorable
The President of the Senate.
The Honorable
The Speaker of the House of Representatives.

Operation Redwing

Early in May 1956, a full-scale series of tests began at the Eniwetok Proving Ground, in the Marshallese Islands of the Pacific. This series, designated "Operation Redwing," incorporated further testing of devices leading toward development of defensive weapons, as well as testing of thermonuclear devices to verify the state of understanding of these weapons.

In order to broaden public knowledge of the effects of thermonuclear weapons, and to provide nongovernmental reporting of the conduct of a test at the Eniwetok Proving Ground, a selected group of 15 news media representatives was invited to witness a detonation of a device with a yield in a range equivalent to millions of tons of TNT (see Information Services). Also included in this special group were 17 observers selected by the Federal Civil Defense Administration. It is believed that this first hand experience provided the observers, and through them the public, with information which will greatly enhance the civil defense effort.

The meticulous safety precautions surrounding the tests, which included a danger area many times larger than the initial area used in the 1954 series, resulted in a 13-day postponement of the shot viewed by public media and civil defense observers due to unfavorable weather conditions (see Biology and Medicine).

The explosive force of the detonation on May 20 of a device dropped from an airplane was, as predicted, substantially lower than the largest yield of the 1954 series. The tests involve weapons generally smaller in yield than those tested during the 1954 series. The energy yield of the largest test falls substantially below that of the maximum 1954 test.

Additions to the Weapons Production Complex

With the two weapons research laboratories, the Los Alamos Scientific Laboratory, Los Alamos, N. Mex., and the University of California Radiation Laboratory at Livermore, Calif., working on new principles, the United States family of weapons in various stages of research, development, and production engineering, is increasing rapidly.

In order to facilitate early production of the weapons conceived in the Livermore Laboratory, it has become necessary to increase weapons production facilities, and to provide ordnance engineering facilities at Livermore, in addition to those currently provided at Albuquerque, N. Mex., by the Sandia Corp., a subsidiary of Western Electric Co.

It has been determined that the expanded ordnance engineering function should be carried out under the current contract with the Sandia Corp. which, since 1949, has been administered by the Albuquerque Operations Office (formerly the Santa Fe Operations Office),[7] and will continue to be administered by that office. The Livermore laboratory itself is operated by the University of California under a contract administered by the San Francisco Operations Office. The expansion is expected to result in a significant increase in employment at the Livermore laboratory, as well as at the Livermore branch of the Sandia Corp.

Construction has begun on an $18.4 million addition to the weapon production facility at Rocky Flats northwest of Denver, Colo. This expansion includes two new process buildings and additions to three existing structures. The project is on schedule and employs a construction force of about 700.

Corresponding necessary expansion of other weapon production facilities is planned.

Some 1,000 personnel of Los Alamos Scientific Laboratory have moved into the new, 4-story General Laboratory and Administration building which was completed recently. This new $6 million structure replaces most of the remaining temporary laboratory buildings built in 1943 and 1945. The new building which provides some 560 offices and contains 210,000 square feet of usable space, stands in the modern technical area on the South Mesa. Plans call for further construction on the South Mesa to replace the remainder of the technical operations buildings in the townsite area on Los Alamos Mesa.

International Affairs

Outstanding among the events related to the international program for development of the peaceful atom was the agreement of twelve sponsoring countries of the United Nations, including the United States and the Soviet Union, on an acceptable basic charter for establishment of an International Atomic Energy Agency. Representatives of 87 nations will be invited to participate in a conference to consider this basic charter at United Nations headquarters in New York during September 1956. This accomplishment grew out of the proposal for international cooperation to advance the peaceful uses of atomic energy which the President made in his historic address before the United Nations General Assembly on December 8, 1953.

[7] See Organization and Personnel.

This has been carried on for several years at Brookhaven National Laboratory to supplement the Commission's quantity production of radioisotopes at Oak Ridge National Laboratory, Oak Ridge, Tenn. Magnesium 28 is the only radioisotope of this element which is practical to use as a tracer. Demand for magnesium 28 from medical scientists and biologists already is very great.

Brookhaven continued its *irradiation service*, averaging during the reporting period about 120 irradiations a month for 30 separate concerns, such as hospitals, industrial firms, and Government agencies. The average number of irradiations for the laboratory's own projects totalled well above 200 a month. In addition, low specific activity cobalt 60 sources were produced in the reactor at the rate of about 1,500 curies per month and distributed to users.

Radiation Effects and Treatment

Effects of Internal Radiation

Effects of internal radiation are under continuing study by the Commission's national laboratories, as well as by other investigators working under Commission sponsorship. Since many of the maximum permissible concentrations (MPC) set for dispersal media (air and water) and published in National Bureau of Standards Handbook 52 are based on limited biological information, a program of research in internal dosimetry has been in progress at Oak Ridge National Laboratory for several years. The work has included spectrographic analysis of tissue for major, minor, and trace, element distribution and concentration in man; studies of the distribution and excretion of enriched uranium in man; pilot studies of distribution and excretion of critical nuclides in research animals to test the validity of MPC values.

Arrangements have been made with medical authorities in different parts of the country to help determine how these elements may vary in man according to age, sex, and place of residence. These data will establish a basis for a "standard" or "average" man upon which calculated MPC values can be made more universally comparable.

*Radioactive Strontium Fall-out**

An estimate of the potential hazards of fall-out from tests of atomic devices was presented by Atomic Energy Commissioner Willard F. Libby during the last 6 months in an address made at Northwestern University, Evanston, Ill., on January 19, and in a scientific paper de-

*Commissioner Thomas E. Murray does not subscribe to this section of the report.

delivered before the American Philosophical Society in Philadelphia, on April 20.

Dr. Libby's conclusion, based on a special Commission study designated "Operation Sunshine", was that the long-term effects of fall-out from high-yield weapons was not as great as generally supposed. A high-yield burst places the major part of bomb debris in the stratosphere, from which it descends slowly over a period of years, he declared in the January address. He cited as the greatest long-term hazard radiostrontium, a chemical relative of calcium which has an average life of about 40 years, high retention in the skeleton, and a low rate of elimination.

The half-life of most of the fission products from high-yield detonations is extremely short, except for strontium. Dr. Libby said, "Nature has wisely provided a built-in mechanism for discriminating against the uptake of radiostrontium in favor of calcium by plants, animals, and human beings."

"From world-wide evidence for fall-out in relation to recent studies of the maximum permissible concentration of strontium 90 in humans," he stated, "it can be concluded that the hazard from the present rate of testing nuclear weapons is insignificant. A total of 11,000 megatons of TNT equivalent of fission [deposited uniformly over the earth] would just yield a strontium 90 content in humans equivalent to the maximum permissible concentration—an amount considered safe. At less than 10 times this value, or below 110,000 megatons energy equivalent of fission, statistically observable incidence of bone tumor should not appear."

At 30 or 40 times the permissible dosage level—or 330,000 to 440,000 megatons—the likelihood of untoward effects would be appreciable, Dr. Libby said, but even the lowest figure he cited—11,000 megatons—was very far in excess of the total energy released to date.

In the April paper, Dr. Libby gave the technical data justifying the conclusions presented earlier. He reported analyses for calcium and for strontium 90 of soils, plants, animals, and foodstuffs obtained from various parts of the world.

Based on studies of the comparative effects of strontium 90 and radium 226 in experimental animals, and of the effects of radium in humans, the generally accepted maximum permissible skeletal content of strontium 90 in humans has been placed at one microcurie. Since the body of the average adult has about 1,000 grams of calcium, this finding would give an estimate of the maximum permissible average concentration of strontium 90 in the adult skeleton at 1 microcurie per 1,000 grams of calcium. In the paper, Dr. Libby used this ratio of strontium 90 to calcium as an "MPC unit" (Maximum Permissible Concentration unit). Bones in growing children have a somewhat er MPC. Even at 10 times the MPC unit, no appreciable occur-

rence of bone tumor should be detected, he said, but at 30 to 40 times the MPC unit, this would probably no longer be the case.

The paper cited analyses of milk from the Wisconsin milk shed area showing an average strontium 90 content of one one-thousandths of the MPC. Foreign milks and cheeses have a strontium 90 content only one-third that of the average in the United States.

One of nature's built-in safety mechanisms as cited by Dr. Libby is that the average milk contains only one-sixth the strontium 90 content of the feed eaten by the cow.

Another mechanism is that strontium 90 deposited on soil does not find its way into water supplies by leaching. The content of rivers and lakes corresponds to only a little more than that accountable by direct fall-out on the surface area of the water.

Analyses of samples of air, rain and soil lead to the conclusion that the strontium 90 contained in the stratosphere would correspond to about 13 millicuries per square mile if it were deposited uniformly over the surface of the entire earth—an amount far below any quantity which might be expected to result in bone tumors if ingested by world population.

Tests of weapons conducted in the Nevada area result in most of the fall-out being deposited locally within the controlled testing area and, therefore, little hazard from the strontium 90 fission products are to be expected on either a United States or world-wide basis. Tests which are conducted in the Pacific are so arranged that the local fall-out is deposited seaward and affects no inhabited atolls.

Measurements of the descent of strontium 90 from the stratosphere indicate that the maximum content of the earth's surface will occur around 1975 with an average world-wide concentration of about one one-hundredth of the maximum permissible concentration. Nature's built-in safety factor previously referred to would lower the content of humans to approximately one one-thousandth MPC unit or less. Thus it appears that at the present level of weapons' testing, the present and potential contribution of strontium 90 to the world ecology is not a significant factor.

Radiation Genetics

It has been known for a number of years that the radiosensitivity of cells changes markedly when they pass through different stages of cell division. In assessing the genetic hazard of radiation, it is necessary to know whether sensitivity to inducement of mutations is increased or decreased as the germ cells mature and, if so, the magnitude of this change. To investigate this problem, experiments were undertaken at Brookhaven National Laboratory to measure this effect in fruitflies.

Fruitfly females were irradiated with both X-rays and thermal neutrons. The females were mated at different intervals after irradiation and the eggs collected. Eggs taken from females mated immediately after irradiation had been irradiated as mature egg cells. Eggs from females mated 10 days after irradiation had been irradiated at the earlier oocyte stage. Eggs from females mated at times between these extremes had been irradiated at intermediate stages of maturation.

Three types of genetic damage have been measured: (1) dominant lethal mutations, (2) X chromosome elimination, and (3) sex-linked recessive lethal mutations.

It was found that oocytes had the fewest mutations and that the frequency of mutation caused by radiation was successively greater as batches of eggs approached becoming mature ova. Dominant lethal mutations showed a far greater increase in mutation rate in successive batches of eggs (between oocytes and mature ova) than did either the X chromosome losses or sex-linked recessive lethals.

In the case of sex-linked recessive lethals, it appeared that radiation-induced mutation never would fall to the so-called spontaneous mutation rate. Progeny from fruitflies which have received a dose of radiation will always carry a larger number of sex-linked recessive lethal mutations. This number will be less if the female is not mated until some time after irradiation.

It was found that the fecundity of animals treated at all stages was about the same in spite of greatly different mutation rates, which means that cells undergo fertilization even when carrying a heavy degree of mutation.

In programs of radiation genetics study, effects of radiation on the genetic constitution have to be sharply differentiated from the genetics of radiation toxicity. Studies under way at the Oak Ridge National Laboratory and in part at Iowa State College essentially fit the first classification. The Argonne National Laboratory genetic studies in the gamma ray toxicity program are concerned with the role of genetic constituents in controlling the radiation response.

In the Argonne experiments four inbred strains of mice and their hybrids are being tested with single and repeated gamma ray exposure. The most obvious observation to date has been that the LD 50/30 (amount of radiation required to cause 50 percent of a population to die within 30 days) varies from strain to strain in such a way as to indicate that there are factors in the genetic constitution that enable certain strains of mice to resist radiation better than others.

There appears to be a single factor in radiation sensitivity, as evidenced by a consistent positive correlation between the response to a single dose of radiation measured by LD 50/30, and the responses to

continuing irradiation measured by the average dose accumulated by populations irradiated for the duration of life.

However, a single sensitivity factor cannot give an adequate description of strain and sex differences for there are changes in the rank order of sensitivity between strains and between sexes within a strain at different daily doses over the range from 200 to 12 roentgen (r) per day. This implies the existence of several independent genetic factors in sensitivity.

Studies of Radiation Tolerance

Although many studies of radiation tolerance have been completed since the Nation's atomic energy program was initiated, a need continues to exist for data that will provide a good quantitative estimate of the amount of ionizing radiation that human beings can tolerate.

At Argonne National Laboratory, research has been under way on the effects of different penetrating radiations on animal and plant systems to help predict the effects of radiation exposure in man. Studies produced curves of survival among animal populations after the experimental animals were exposed to pure fast-neutron radiation and pure gamma rays. The mechanisms in animals of the effect of these two types of radiation apparently were somewhat different.

When the animals were exposed to fission (fast) neutrons, a certain total amount of neutron irradiation would produce the same survival pattern even when the amount of irradiation given in a single dosage was greatly reduced. In fact, for a given total exposure, the LD 50/30 remained the same even when the rate of exposure was reduced by a factor of 16. This was not true for gamma rays. Decreasing the dose rate of gamma radiation by a factor of 16 increased by 40 percent the amount of radiation required to produce the LD 50/30 dosage. The number of survivors also increased when the gamma ray dose rate was lowered.

An important result from the study was the observation that in a range of dose with neutron radiation, most deaths occurred within 3 to 5 days after a lethal irradiation; while with cobalt 60 gamma rays, most of the deaths did not occur until 12 to 15 days after irradiation.

A very basic observation was made in this study. The effects of one type of radiation supplemented the effects of the other type, that is, at certain gamma ray dose levels the addition of an equivalent dose of neutron radiation resulted in a death rate predictable in most cases from known LD 50/30 values. When the gamma component of the mixed radiation was reduced below these levels, the additive effect weakened somewhat. This departure from additivity was exhibited only for deaths occurring during the early period after exposure—

before the ninth day. After the twelfth day the probability of death was completely predictable on an additive basis, even with the gamma component reduced.

Work with mixtures of neutron and gamma radiations at sublethal levels is being continued to determine the very important question of the additive effect of mixtures of these radiations in producing such delayed effects as tumor incidence, cataract formation, and shortening of life span.

The studies of toxicity from acute neutron exposure have been largely completed and present work at Argonne emphasizes the chronic effects of sublethal doses of neutron radiation and the relative biological impact of neutron and gamma radiations. With completion of the Argonne CP–5 reactor, one face of which was modified and reserved for animal experimentation, it became possible to irradiate experimental animals in a much wider range of neutron fluxes than was previously available. An additional feature was that the neutron intensity was more uniform throughout the field. With this improvement, a large number of animals can receive approximately equal doses of fast neutrons in contrast to earlier experiments where only small groups could receive uniform exposure at a time.

The gamma radiation facility consists of two underground rooms—a so-called low level room, and a high level room—with concrete walls and ceilings and interior dimensions of 18 by 25 by 25 feet. The high level room contains two cobalt 60 sources—1,000 and 100 curies respectively—each of which can be preselected and raised to a predetermined height by remote control mechanisms. This room has been in operation for approximately 2 years. The low level gamma ray room differs only in the strength of the cobalt 60 source which is about 7 curies.

Through proper selection of the source and placement of animals, it is possible to irradiate whole populations of animals at dose-rates ranging from less than 1 roentgen per day to 10,000 roentgen per hour. A total population of animals can be irradiated at different dose-rates at one time under identical environmental conditions.

In one program of gamma irradiation studies, three basic radiation patterns are being observed: base-line duration-of-life exposures; split-dose; and single-dose exposures.

In the base-line duration-of-life exposures, approximately 5,000 to 6,000 mice will be used. Thirty-two dose-rates ranging from 6 to 10,000 *r* per day are being used and from 2 to 15 independent replications are entered at each dose level. The interest lies in establishing the radiation dose that will cause a given response. From this study it is hoped to determine the maximum amount of radiation which a population can receive on a continuing basis without suffering an observable effect that is statistically significant. It is expected that

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the tests may determine the base-line for effects such as observable changes in the blood or blood systems, tumor incidence, and tissue changes. The study will also provide detailed analysis of the critical regions where dose rate sharply changes survival patterns.

One feature observed after radiation exposure is an apparent physiological aging of the animal. In all the studies mentioned above, male and female animals are being used to compare the response of each sex to clarify the processes of aging with accumulated radiation injury. Compared with man, the age groups studied represent the young, mature, and middle-aged adult.

Histological (tissue), cytogical (cell), and histochemical studies are being done on all animals undergoing continuous exposure to gamma radiation. Classification and quantitative evaluation of cell and tissue changes are being made with particular emphasis on the intestines, the testes, and the liver.

In the small intestine, the crypt cells are severely damaged at all dosage levels above 43 roentgen per day. The damage reaches a peak in the first 3 to 5 days following the beginning of exposure. Crypt cells that survive this initial period apparently can give rise to sufficient mucosal cells to maintain the epithelial lining and after 30 days, repair of the intestinal lining is essentially complete and cell multiplication indices are approaching normal.

In the testes approximately all elements are gradually depleted to the point of their complete elimination at all dose levels studied. At any given daily dose the rate of elimination is proportional to the duration of the exposure. There is no evidence of recovery.

In the liver little histological or cytological change occurred but histochemical studies revealed a drastic reduction in glycogen content.

In blood studies the reticulocytes (young blood cells) showed perhaps the most interesting results. There was an abrupt fall to a minimum quantity within 3 days after irradiation at all levels examined, followed by a rise that appeared even after the highest daily radiation dosage levels (56 roentgen per day) and the level did not fall again until near the end of life. High reticulocyte levels coexisted with a low red-blood corpuscle count and the phenomenon is not accounted for. Possibilities are that radiation increases the maturation time of the reticulocytes, that it decreases the life span of the reticulocyte, or that it causes some fraction of the young red blood corpuscle population to suffer heavy mortality.

Radiation Dosimetry

Oak Ridge National Laboratory has developed various methods of measuring the dose due to fast neutrons which make possible a

determination of the neutron dose in the presence even of high intensity gamma radiation.

These methods use a proportional counter applicable to general neutron monitoring and laboratory studies, and a series of threshold detectors especially for measurements of neutron dose from nuclear weapons tests. The threshold detector method was used in Operation Teapot, the Nevada weapons tests of 1955, to determine neutron spectra and dose as a function of distance from the various types of devices tested.

Treatment of Irradiation Injury

It has been known for several years that an injection of living blood-forming cells taken from the bone marrow or spleen would enable survival of an irradiated animal that otherwise would die. Much evidence has been presented which demonstrates that blood-forming cells will transplant and grow when placed in the abdominal cavity and other sites of an irradiated or normal animal. In the irradiated animal, it also was shown that blood-forming cells from another species would transplant and grow for at least limited periods of time. Recent important experiments from a number of laboratories have demonstrated that when blood-forming cells are injected into the blood stream of an irradiated animal, they go to the irradiated animal's blood-forming organs (bone marrow, spleen, lymph nodes) where they may multiply and replace the blood-forming cells destroyed by the irradiation.

It was shown by scientists in England, using a strain of mice with easily identifiable chromosomes, that the spleen blood-forming cells of a mouse from this strain, after intravenous injection, went to the blood-forming organs of the irradiated mouse. The English workers also showed that the irradiated mouse that was injected intravenously with rat bone marrow cells subsequently developed bone marrow cells that showed the rat type and number of chromosomes.

At Oak Ridge National Laboratory experiments during the past few months have shown that the new transplanted bone marrow produced functioning blood cells. It was demonstrated with immunologic techniques that bone marrow cells from one type of rat produced that type of red blood cell when injected into another type of rat that had been irradiated. Using an immunologic technique, Oak Ridge also showed that rat bone marrow injected intravenously into an irradiated mouse subsequently caused the mouse to have only rat red-blood cells.

National Academy of Sciences Radiation Studies

The initial report of a study by the National Academy of Sciences, "The Biological Effects of Atomic Radiation" was issued in June 1956.[27] The study, financially supported by a grant from the Rockefeller Foundation, was begun last year by a group of distinguished scientists who undertook to make initial findings and recommendations on the effect of radiation on human beings and their environment based on analyses of accumulated data in the areas of genetics, pathology, waste disposal and dispersal, oceanography and fisheries, meteorology, and agriculture and food supplies.

The Commission cooperated with the National Academy by providing data resulting from the extensive research programs which the Commission has sponsored on the biologic effects of nuclear radiation. A major part of the research upon which the report was based was conducted under Commission sponsorship. The Commission is giving the report careful study, and will continue to assist the Academy.

In a statement issued when the report was made public, the Chairman of the Commission said that the Academy study "represents a public service of major importance," and congratulated the Academy and the distinguished scientists who participated in its findings for the issuance of "a constructive and independent study."

The Foreword of the Academy report states that "the use of atomic energy is perhaps one of the few major technological developments of the past 50 years in which careful consideration of the relationship of a new technology to the needs and welfare of human beings has kept pace with its development. Almost from the very beginning of the days of the Manhattan Project [the wartime atomic energy agency] careful attention has been given to the biological and medical aspects of the subject. By contrast, the automobile industry revolutionized our pattern of living and working, but we are only now beginning to appreciate the problems of safety, urban congestion, nervous tension, and atmospheric pollution which have accompanied its development. In the same way, the development of the aircraft industry outran our knowledge of how to meet the environmental needs of the human beings it intended to transport through the skies."

The following statement was among the major conclusions of the report:

"Thus far, except for some tragic accidents affecting small numbers of people, the biologic damage from peacetime activities (including the testing of atomic weapons) has been essentially negligible. Furthermore, it appears that radiation problems, if they are met intelli-

[27] See p. 92, Eighteenth Semiannual Report (January–July 1955).

ently and vigilantly, need not stand in the way of the large-scale development of atomic energy. The continuing need for intelligence and vigilance cannot be too strongly emphasized, however."

WASTE DISPOSAL RESEARCH

The production of large volumes of liquid radioactive wastes as byproducts of the operation of reactors and chemical processing plants has posed challenging economic and radiological problems since the beginning of the industry.

For many years at the Hanford Works, Richland, Wash., large volumes of liquid wastes of low level radioactivity, such as contaminated reactor-cooling waters, have been disposed of to the ground or to the Columbia River under controlled conditions. Highly radioactive solutions of fission products from the separations plants have been stored in large underground steel tanks for eventual reworking, or for a lessening of radioactivity through decay that would permit safe release to the environment.

One aspect of the problem studied under the Commission's biophysics research program was the movement of radioactive elements through the soil into ground water, and with the ground water toward points of possible use. Laboratory and field investigation in the earth sciences has clarified the behavior of the most significant isotopes and has shown that, through ion exchange, soils can remove the more hazardous materials. Isotopes of low exchangability were found generally to be those of shorter half-life or of lower abundance.

The Hanford area generally has several hundreds of feet of dry soil lying above the water table, and this in turn lies above highly impermeable basaltic lava flows thousands of feet thick. While the active clay fraction of the soils is small, conditions were found to be highly conducive to the removal from solution of cesium 137, strontium 90, rare earths, plutonium and uranium—the more significant contaminants in the wastes. Ruthenium 106 (12-month half-life) was little adsorbed but is of less concern due to the estimated times it takes ground water from disposal points to reach the river.

A somewhat similar problem has been the return of reactor cooling water directly to the Columbia River. In passing through the reactor the water becomes contaminated by the radioactivation of residual or other impurities, or by introduction of radioactive materials from the reactor fuel or water tubes. Most isotopes so produced decay during the short hold-up period before the water is released to the river, but certain ones persist, such as sodium 24, manganese 56, arsenic [illegible], coper 64, phosphorus 32, calcium 45, strontium 89 and 90, barium

140, zinc 65, iron 59, chromium 51, and rare earths. However, the studies have established that contamination of water at points of domestic water intake below Hanford has averaged less than 2 percent of the limit set by the U. S. Bureau of Standards Handbook 52. Extensive analysis work on the reactor effluents before and after dilution by the river have produced these findings—and also have led to the development of unique sampling methods, refined analytical techniques, and automatic monitoring equipment.

A major objective of the waste disposal program at Oak Ridge National Laboratory is to develop and evaluate methods for safe disposal into the ground of high level radioactive wastes. First work was on fixation of typical reactor process wastes into ceramic masses of earth materials, and fluxes admixed with the wastes. The studies now have been extended to include pilot scale experiments using field pits for disposal. Solid clinkers containing the essential waste constituents are formed by prolonged heating at high temperatures of the waste-flux admixtures after they are placed in the pits. Concurrent studies determine the heating requirements, uniformity of the ceramic mass, adequate fixation of the radionuclides in the clinker, evolution of aerosols during heating, and methods for preventing excessive dispersion of waste materials into the surrounding air, water or soil

Studies have continued on surface pits excavated in the Conasauga shale formation and used for disposing of intermediate level radiochemical liquid wastes from Oak Ridge. The geologic and hydrologic conditions in the waste pit area have been defined more completely. Field investigations in progress, and related laboratory studies, are designed to determine more definitely: (1) the volume of liquid wastes seeping into the shale, (2) the retention of radionuclides in the soil formations, (3) the pattern of the underground flow of chemical wastes in comparison with the flow of ground water, and, (4) if required, practical means for minimizing the seepage of wastes from the pits into the shale.

Increased and more specific studies are being made to determine the dispersion of waste constituents to the environment and the potential hazard to human, plant and animal life. Dispersion of wastes in ground water, surface water, and the soil is being estimated by (1) test wells; (2) stream gaging; (3) radiation measurements; and (4) sampling and analyses of water and soils. Current studies of the ecological aspects include (1) laboratory investigations of the effects of radiation on specific soil organisms and animals; (2) uptake of radionuclides by soil organisms and vegetation; and (3) preliminary field studies on the long-term biological effects of wastes released into the soil.

Safety Precautions At Weapons Tests

During Operation Redwing test series at the Eniwetok Proving Ground in the Pacific, elaborate precautions are being taken to protect health and assure safety. A danger area of some 375,000 square nautical miles, roughly rectangular in shape, was blocked out and notifications broadcast more than 2 months in advance of the tests. Within the danger zone, there were no inhabited lands—no installations except for some test facilities. Regular air and sea searches of the danger area were carried out. As reported by news observers, before the Cherokee shot, a Japanese fishing craft was found on the perimeter of the area and escorted to safe regions.

The major safety precaution, aside from blocking out and patrolling the danger zone, was selection of a weather condition which was not only favorable for a shot but which would assure that the radioactive fall-out would come within the danger zone. Special studies of tropical weather, and methods of forecasting, were worked out for this purpose.

In addition, in areas outside the danger zone, arrangements were made for emergency evacuation of island inhabitants should this prove necessary, due to shift in winds or some other unforeseeable occurrence. After a detonation, the fall-out was monitored by plane crews tracking the radioactive cloud, and by radiological experts stationed on peripheral inhabited islands, and at stations of the weather reporting network. Fall-out also was monitored throughout the world.

In the United States itself, 39 monitoring stations are located in various cities across the country. Twenty-seven of these stations have been set up by the U. S. Public Health Service and 12 stations by the Atomic Energy Commission. Samples collected by these stations are forwarded to the Commission's Health and Safety Laboratory in New York for immediate analysis and evaluation. At approximately 70 locations throughout the world, in addition to the stations in the United States, monitoring stations are also set up.

A program to make measurement of radioactivity in sea water and in marine organisms is being conducted in the Pacific. Readings of radioactivity in the surface water are taken and water samples are collected at various depths below the surface. Plankton and fish are analyzed for possible radioactivity. After the test series, marine surveys will continue and will extend as far westward as radioactivity is detectable. In addition, land and marine biological surveys will be conducted on Eniwetok and Bikini Atolls and in the lagoons.

Further details on safety arrangements are described in Appendix [illegible], a background paper issued to observers during Operation Redwing.

Civil Defense Activities

During the first half of 1956, there was an increasing tempo of interchange of information with, and assistance to, the Federal Civil Defense Administration, by the Atomic Energy Commission.

Participation in Nuclear Tests

The extensive participation of the Federal Civil Defense Administration, and of other Federal agencies and industrial organizations in Operation Teapot through Federal Civil Defense Administration sponsorship was described on pp. 81–83 in the Eighteenth Semiannual Report (January–June 1955). Joint planning for further Civil Effects Tests on an even broader scale is under way and preliminary conferences have been held at Washington and at Federal Civil Defense Administration headquarters in Battle Creek, Mich., between representatives of the Commission, FCDA, and other interested agencies. The final Civil Effects reports of 0peration Teapot are being issued with emphasis placed on elimination, or segregation, of classified material, so that a large mass of information on the civil effects of nuclear detonations can be released, not only to civil defense organizations, but also to the general public.

Distribution of these reports already is under way; the majority of the final reports will be completely unclassified. The preliminary reports which they supersede were widely distributed.

Arrangements were made for an FCDA representative to be assigned to the Joint Task Force staff througout Operation Redwing at the Eniwetok Proving Ground this year to keep FCDA currently informed of test developments pertinent to civil defense planning. This follows previous practice except that, in the current operation, the FCDA representative is not an observer, but is assigned directly to the Scientific Task Group of the Joint Task Force.

In addition 17 FCDA-designated special observers viewed two detonations of Operation Redwing at the invitation of the Commission and the Department of Defense.

Technical Assistance

The Commission is expanding its scientific and technical assistance by adding consultant services to assist in civil defense matters. The Health and Safety Laboratory, New York Operations Office, is helping FCDA develop specifications and procure equipment for aerial monitoring of radiation. The feasibility of the technique was demonstrated during Operation ARME, conducted at the Nevada Test Site in October 1955 for FCDA-sponsored personnel.

Loans of Radiation Sources

Cobalt 60 sources were lent to civil defense organizations of the States of New Jersey, Maryland, Delaware and Washington, and the city of Tacoma, Wash., for civil defense demonstration and training purposes, upon endorsement by the FCDA. A larger, 3-curie cobalt source has been made available to the State of Georgia for radiation detection instrument calibration. Sources and dosimeters were lent to FCDA National Headquarters and Region IV for use in instructor training courses.

Eligibility of several FCDA Headquarters and regional radiological defense personnel to receive and use radioactive sources was established.

Revision of "The Effects of Atomic Weapons"

"The Effects of Atomic Weapons," published jointly by the Commission and the Department of Defense in June 1950 as a definitive handbook is currently undergoing revision to include the latest knowledge of weapons effects gathered by experiment and observation in laboratory work and test series since preparation of the first issue of the handbook. Publication is scheduled for early 1957 under the title "Effects of Nuclear Weapons."

Security

During the last 6 months, the Atomic Energy Commission revised the criteria and administrative review procedures for determining the eligibility for security clearance of persons in the atomic energy program or entering it. The Commission announced the revision on May 10, 1956, and published the regulation that same day in the *Federal Register*, to take effect immediately.[28] The last revision, which took place in 1950,[29] extended to prospective employees the right to a hearing which previously had been limited to employees.

Eight years of experience in the field of personnel security clearances, and the recommendations of representatives of the scientific community contributed to the current revision. In January 1955, at a conference of the directors of eight Commisson laboratories, it was recommended that a committee [30] of scientific, legal, and security per-

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[28] The regulation is printed in Appendix 7.

[29] See p. 35, Ninth Semiannual Report (July–December 1950).

[30] The committee included Dr. Norris E. Bradbury, Los Alamos Scientific Laboratory, Los Alamos, N. Mex.; Dr. Ernest O. Lawrence, University of California Radiation Laboratory, Berkeley, Calif.; Dr. Walter H. Zinn, Argonne National Laboratory, Lemont, Ill.; Dr. Clarence E. Larson, Oak Ridge National Laboratory, Oak Ridge, Tenn. (succeeded by Dr. Alvin Weinberg); William Mitchell, General Counsel of the Commission; John A. Waters, Security Division of the Commission.

APPENDIX 8

Statements Issued by White House on Allocation of Uranium 235, February 22, 1956

Statement by the President

Mankind's hopes and aspirations for peace and greater well-being are closely linked to the world's progress in developing the peaceful uses of atomic energy. The program to further this development has advanced steadily in the past two years.

I am announcing today further steps by the United States toward the production of peaceful power from the atom.

At the recommendation of Chairman Lewis L. Strauss of the U. S. Atomic Energy Commission, in which the Departments of State and Defense concur, I have determined, under Section 41b of the Atomic Energy Act of 1954, that substantial quantities of the special nuclear material uranium 235 may now be designated for research and development purposes and for fueling nuclear power reactors at home and abroad. This material will be available for either sale or lease under conditions prescribed by the United States Government. The Commission's recommendations are based on extensive studies that have been in progress since enactment of the Atomic Energy Act of 1954.

The quantities of uranium 235 which will be made available for distribution over a period of years under this determination are:

a. In the United States, through lease for all licensed civilian purposes, principally for power reactors—20,000 kilograms.
b. Outside the United States, through sale or lease for peaceful purposes, principally power and research reactors—20,000 kilograms. This is in addition to the 200 kilograms already made available for research reactors abroad.

It is not intended that nations which are presently producing uranium 235, or the Soviet Union and its satellites, shall share in this distribution.

Distribution of special nuclear material will be subject to prudent safeguards against diversion of the materials to non-peaceful purposes.

The quantities of uranium 235 to be made available as a result of this determination will permit us to carry out our responsibilities in the development of atomic energy for the common defense and security of the United States and for contributing to the peace and general welfare of the world.

Significant actions are under way to create an international agency and an integrated community for Western Europe to develop peaceful uses of atomic energy. The United States welcomes this progress and will cooperate with such agencies when they come into existence.

The special nuclear material to be made available will support the start of nuclear power programs with a generating capacity of several millions of electrical kilowatts. With this assurance, such programs may be undertaken in the next several years, in this country and abroad.

As additional projects are undertaken by our industry and by other nations, more nuclear fuel will be required. The Atomic Energy Commission has informed me that it will recommend that additional supplies be made available as become necessary in the future.

This action demonstrates the confidence of the United States in the possibilities of developing nuclear power for civilian uses. It is an earnest of our faith that the atom can be made a powerful instrument for the promotion of world peace.

Statement by Lewis L. Strauss, Chairman, U. S. Atomic Energy Commission

The President's action in authorizing the Atomic Energy Commission to make available 40,000 kilograms of uranium 235 for use here and abroad in the development of nuclear power is the most important step toward peaceful uses of atomic energy since the passage of the Atomic Energy Act of 1954.

The President's action has two major aspects:

It authorizes the Atomic Energy Commission to provide sufficient uranium 235 to meet the estimated requirements of the private and public power groups in the United States which, in the role of pioneers, have announced plans for the construction and operation of nuclear power plants.

It enables the Commission to respond to the top-priority question concerning the availability of nuclear fuel being asked by our friends abroad who wish to negotiate agreements with the United States for assistance in developing their respective nuclear power programs.

We are now embarking on programs of aid in nuclear power development, extending beyond our previous programs of support of atomic energy research in the United States and abroad. Under these new programs we will provide uranium 235 to support nuclear power development during the life of the licenses issued under our civilian applications program at home and the expected life of agreed power reactor projects abroad using our fuel. The 40,000 kilograms of uranium 235 available to domestic and foreign users will not all be distributed in the coming year or in any other single year. It will be distributed over a period of years as needed, with smaller amounts in the early years.

Prior to the President's action today, the United States offered to make available, within prudent security considerations, to friendly nations prepared to invest their own funds in nuclear programs both access to and training in the new technology of theory, design, construction and operation of power reactors.

We have carried out that promise in several ways. At the International Conference on the Peaceful Uses of Atomic Energy held in Geneva in August 1955, the United States presented along with the valued contributions of other nations, much data useful in nuclear power research and development. We also have encouraged friendly nations to seek, under mutually acceptable standards of necessary security, more precise data and assistance in the power reactor field.

The research type of bilateral agreements for cooperation now in effect with nations contain these words:

> "It is the hope and expectation that this initial agreement. . . . will lead to the consideration of further cooperation extending to the design, construction and operation of power-producing reactors."

Several nations are presently negotiating with us for the type of agreement envisioned in the bilateral research agreements.

As for training representatives of friendly nations in the new technology of power reactors, we have organized a special school at the Commission's Argonne National Laboratory from which 40 scientists and engineers already have been graduated and 30 more are now attending classes. These 70 men come from 29 nations. It is planned to extend this training. Among other means will be a proposed educational and research institution in the Far East.

In the present state of the nuclear art, countries with available water power or supplies of coal and oil will, for some time to come, find it more economic to build and operate conventional power plants.

The authorization of 20,000 kilograms of uranium 235 to be made available for lease to civilian users in the United States was based on estimates of current and future needs. These include the needs of existing licenses and pending applications for licenses as well as proposals received by the Commission—including proposals under the Power Demonstration Reactor Program—which seem likely to lead to the filing of license applications during the current fiscal year ending June 30, 1956.

Only part of the special nuclear material will be distributed in any one year. Licenses may be issued for a varying period extending up to 40 years, and delivery of uranium 235 to licensees will be spread over the life of the licenses, to permit start-up of reactors and replacement of fuel as required in later years.

The uranium 235 will be distributed under provisions of Section 53 of the Atomic Energy Act of 1954 and will be allocated to specific licensees only on the basis of a Commission determination of the licensee's need for the material.

The procedures which will govern the distribution of the 20,000 kilograms of uranium 235 to be made available to other countries, as well as charges for sale or lease, will be announced in the near future. However, based on the value of $25 per gram of contained uranium 235 for enriched uranium leased for research reactors, as announced by the U. S. Atomic Energy Commission at the International Conference on the Peaceful Uses of Atomic Energy, the 40,000 kilograms of uranium 235 now made available for such sale or lease would have a value of one billion dollars.

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APPENDIX 9

Public Health and Safety Precautions for Eniwetok Tests

Protection of the public health and safety is a primary consideration in the conduct of the nuclear tests which will begin in the spring of 1956 at the Eniwetok Proving Ground.

Various precautions have been taken to keep significant radioactive fallout within the confines of the danger area in the Pacific which was announced on March 1, 1956. With the exception of Joint Task Force facilities, there are no inhabited places within the danger area.

There is no reason to expect that hazardous fallout will occur outside the danger area, and it is highly unlikely that any inhabitants of atolls will have to be moved. However, complete plans have been made for transportation of the inhabitants should such action have to be taken.

Elaborate systems have been established to detect and measure radioactivity in the vicinity of the Proving Ground, in the United States, and in other parts of the world. In addition, extensive marine surveys will be conducted to measure radioactivity in sea water and marine organisms.

More detailed information on health and safety measures relating to the test series follows:

FALLOUT PREDICTIONS

Tests will be conducted only when the forecast pattern of significant fallout is entirely within the danger area, in which there are no inhabitants. In forecasting fallout patterns, scientists will make use of improved methods of collecting and evaluating data which have been developed as a result of intensive study of the problem of predicting fallout in the vicinity of the Proving Ground.

Fallout predictions are dependent upon the accuracy of weather information. The weather reporting network which will be utilized for the 1956 tests will be larger than those in effect during any previous operation. Additional surface and upper air observing stations have been established, and improved equipment and techniques have been developed to increase the altitude and improve the accuracy of weather observations. As a result, more complete and earlier weather information will be provided.

Research has been conducted in the special field of tropical meteorology, and weather observers and forecasters have been instructed in the new methods of forecasting which have been developed as a result of these studies.

Trained personnel have been organized into a fallout prediction unit. They will utilize newly-developed fallout computers, will assist in predicting fallout patterns by mechanizing most of the mathematical procedures involved. Use of the computers is expected to allow forecasts to be made much more rapidly than heretofore, so that the final decision to conduct or postpone a test can take last-minute weather observations into account.[1] Models of the clouds produced by large-

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[1] The fallout computer, designed by the National Bureau of Standards, works in the following way:

Weather information and estimates of the diameter and height of the cloud and the distribution of radioactivity within the cloud are fed into the computer by setting various dials. One-twentieth second after the data is set up, the machine visually displays a predicted fallout pattern on the face of a television-like tube. The predicted radioactive intensity at any point up to 250 miles or more from ground zero is indicated by the brightness of the pattern at the particular point in question.

scale nuclear detonations have been developed as a result of experience gained from the 1954 testing operations, and these also are expected to improve fallout predictions.

With better weather information, more accurate cloud models, and faster procedures made possible by computing machines, the fallout prediction unit will be able to make much more rapid and accurate forecasts of fallout patterns than was possible two years ago. Tests will be conducted only when significant fallout is predicted entirely within the danger area.

ENERGY RELEASE OF DETONATIONS

As announced on March 1, 1956, the 1956 tests will involve weapons generally smaller in yield than those tested during the 1954 series. The energy release of the largest 1956 test is expected to be substantially below that of the maximum 1954 test.

DANGER AREA

The danger area is generally rectangular in shape and comprises roughly 375,000 nautical square miles. Its boundaries were announced on March 1, 1956. While slightly smaller than the danger zone used in the latter part of the 1954 series, the area is many times larger than the initial danger area used in 1954, and has been reoriented slightly for increased safety. Outside of the test facilities, no inhabited atoll is within the area.

All ships, aircraft and persons have been cautioned to remain clear of the danger area by notices which have been given the widest possible distribution through United States and international marine and aviation organizations. The Department of State has notified all Diplomatic Missions in Washington of the extent of the area.

Regular air and sea searches of the area will be conducted in advance of the start of operations. Before each shot, the patrol of the danger area will be intensified, particularly in the area where fallout is forecast.

RADIATION MONITORING IN PROVING GROUND REGION

After each detonation, aircraft will track the radioactive cloud. In addition, aircraft using aerial monitoring equipment will survey populated areas south and east of the Proving Ground to detect any radioactivity on land masses and on the surface of the sea.

Radiological safety personnel, equipped with radiation detection and measuring instruments and two-way radios to enable them to communicate with the central Task Force Radsafe Office, will be stationed on the nearby inhabited atolls to the east and south of the Proving Ground, and at weather stations of the weather reporting network. In the unlikely event of significant fallout in an inhabited area, the monitors would warn the inhabitants and advise and assist them in taking safety measures. The monitors also will train Marshallese medical practitioners and health aids in basic emergency measures.

EMERGENCY PLANNING

As a result of the monitoring procedures described above, the Task Force will have warning should an unexpected wind shift carry the cloud toward an inhabited area, and also will receive information by radio on the levels of radioactivity on the inhabited atolls.

It is not expected that there will be need to move any of the inhabitants at any time during the test series. However, as a precaution, complete plans have been prepared for transporting persons from populated atolls in the event that such action were considered advisable.

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RADIATION SURVEYS OF SEA AND MARINE LIFE

Outside of the testing area, the detonations are not expected to produce levels of radioactivity in the ocean which would be hazardous to marine life or to persons eating food fish. However, an extensive program of measurements of radioactivity in the sea water and in marine organisms will be conducted.

Beginning about June 10, a fast U. S. Navy vessel will work westward from the test site, making sweeps between 10 and 14 degrees North latitude west as far as fallout radioactivity can be detected.

Continuous readings of radioactivity in the surface water will be taken by means of a device which pumps water around a detection instrument in a tank on the deck of the ship. The ship will stop each 25 miles to take samples of the water at the surface and at depths of 25, 50, 75 and below 100 meters.

Personnel aboard the ship also will make tows for plankton—tiny marine organisms which tend to concentrate radioactive materials in their tissues. Fish will be caught, and analyzed for radioactivity.

After the series, when test radioactivity will have moved further away from the test site, a similar survey will be carried out as far west as radioactivity can be detected.

The Commission also has entered into a contract with the George Vanderbilt Foundation at Stanford University, under which scientists will collect samples of water, plankton, marine invertebrates and fish in the vicinity of the Palau Islands. These samples will be sent to the biological laboratory at the Hanford Works for analyses.

In addition to these investigations, land and marine biological surveys will be conducted on Eniwetok and Bikini atolls and in their lagoons. Samples of water, lagoon life, and animal life on the atolls will be collected and analyzed for radioactivity.

FALLOUT MONITORING IN UNITED STATES

The heavier particles fall out of the radioactive cloud at early times after a detonation, while their radioactivity is still high. Therefore, the highest levels of radioactivity occur over a local area downwind from the point of detonation. The area of significant fallout is expected to occur entirely within the uninhabited danger area surrounding the Eniwetok Proving Ground.

As the radioactive cloud is transported away from the point of detonation, it is widely dispersed by air currents and diluted by normal air. Its radioactivity also decreases rapidly because of the normal process of radioactive decay.[2] By the time the cloud from an Eniwetok test has traveled eastward across the ocean, it will have become a dispersed, invisible air mass, which has lost much of its original radioactivity.

As a result, the levels of radioactivity in the United States from the Eniwetok tests are expected to be low. Levels of 10 or more times the normal background may be reached in some localities at some times. However, these increases in background will be temporary, and will result in exposure far below amounts which would affect the health of exposed persons.

As it has in the past, the Commission will conduct extensive radiological monitoring operations within the United States during the test series. These operations are not conducted in the expectation of possible hazard, but for scientific purposes and to keep the public informed on levels of radioactivity.

[2] Radioactive fallout consists of a mixture of radioisotopes, with varying half-lives. The mixture as a whole decreases in radioactivity in such a way that for every seven fold increase in age, the total radioactivity is decreased 10-fold. Thus, the radioactivity at seven hours after the explosion is only one-tenth that at one hour, and in 49 hours is one-hundredth, etc.

Two types of monitoring operations will be conducted within the United States. One will consist of a network of U. S. Weather Bureau stations, which collect fallout samples at selected locations throughout the nation. The collection method is simple. A sheet of film covered with an adhesive is exposed outdoors on a tray for 24 hours, and then is mailed to the Commission's New York Health and Safety Laboratory. There, the sample is reduced to ashes, and the ashes are monitored with sensitive laboratory instruments. Very minute amounts of radioactivity can be measured by this technique.

During the 1956 series, the following Weather Bureau stations will make fallout collections:

Albuquerque, N. Mex.
Atlanta, Ga.
Billings, Mont.
Binghamton, N. Y.
Boise, Idaho
Boston, Mass.
Chicago, Ill.
Cincinnati, Ohio
Cleveland, Ohio
Concord, N. H.
Corpus Christi, Tex.
Dallas, Tex.
Des Moines, Iowa
Detroit, Mich.
Grand Junction, Colo.
Hatteras, N. C.
Jacksonville, Fla.
Knoxville, Tenn.
Las Vegas, Nev.
Los Angeles, Calif.
Louisville, Ky.
Medford, Oreg.
Memphis, Tenn.
Miami, Fla.
Minneapolis, Minn.
New Haven, Conn.
New Orleans, La.
New York (La Guardia), N. Y.
Philadelphia, Pa.
Pittsburgh, Pa.
Rapid City, S. Dak.
Rochester, N. Y.
St. Louis, Mo.
Salt Lake City, Utah
San Francisco, Calif.
San Juan, P. R.
Scottsbluff, Nebr.
Seattle, Wash.
Tucson, Ariz.
Washington, D. C. (Silver Hill, Md.)
Wichita, Kans.

This collection system does not provide immediate information on dose rates, since the samples must be mailed to the Health and Safety Laboratory and counted there. However, the information collected has varied scientific uses. It is needed by the Commission to compute and record the overall accumulation of radioactivity as a result of tests. It is needed by the photographic industry and by scientists conducting experiments with low-level radiation, since these activities can be affected by even a very slight increase over the normal background. The data also are used by meteorologists to trace air masses and check predicted trajectories.

More rapid information on radiation levels will be provided by 39 monitoring stations located in cities across the country.

Twenty-seven of these stations have been set up by the U. S. Public Health Service, which has been furnishing fallout monitoring services to the Commission for the past two years in States near the Nevada Test Site. At the Commission's request, the Public Health Service has established an expanded monitoring program which will be in operation with the forthcoming test series.

The monitoring stations established by the Public Health Service will collect daily readings of radioactivity and forward the data to a central collection office in Washington. The monitoring stations also will report data to the State Health Officers of the States in which the stations are located.

The primary purposes of the network are to give State and local health departments more experience in studying fallout and normal background radiation levels, and to obtain daily records

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in the following cities:

Lawrence, Mass.
Hartford, Conn.
Albany, N. Y.
Bethesda, Md.
Gastonia, N. C.
Atlanta, Ga.
Jacksonville, Fla.
New Orleans, La.
Austin, Tex.
Berkeley, Calif.
Salt Lake City, Utah
Richmond, Va.
Los Angeles, Calif.
Portland, Oreg.
Oklahoma City, Okla
Jefferson City, Mo.
Cincinnati, Ohio
Indianapolis, Ind.
Springfield, Ill.
Des Moines, Iowa
Lansing, Mich.
Minneapolis, Minn.
Las Vegas, Nev.
Seattle, Wash.
Trenton, N. J.
Denver, Colo.
Honolulu, T. H.

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Ohio
Oak Ridge National
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radioactivity. The stations will be manned by trained technicians from state health departments, local universities, and scientific institutions.

Monitoring stations in the Public Health Service network will be located in the following cities:

Lawrence, Mass.
Hartford, Conn.
Albany, N. Y.
Bethesda, Md.
Gastonia, N. C.
Atlanta, Ga.
Jacksonville, Fla.
New Orleans, La.
Austin, Tex.
Berkeley, Calif.
Salt Lake City, Utah
Richmond, Va.
Los Angeles, Calif.
Portland, Oreg.
Oklahoma City, Okla.
Jefferson City, Mo.
Cincinnati, Ohio
Indianapolis, Ind.
Springfield, Ill.
Des Moines, Iowa
Lansing, Mich.
Minneapolis, Minn.
Las Vegas, Nev.
Seattle, Wash.
Trenton, N. J.
Denver, Colo.
Honolulu, T. H.

In addition to the Public Health Service network, monitoring stations set up by the Commission will collect data at 12 locations, listed below:

Atomic Energy Project, Salt Lake City, Utah

University of California Radiation Laboratory, Berkeley, Calif.

Argonne National Laboratory, Lemont, Ill.

Atomic Energy Project, Rochester, N. Y.

Los Alamos Scientific Laboratory, Los Alamos, N. Mex.

General Electric Co., Aircraft Nuclear Propulsion Dept., Evendale, Ohio

Oak Ridge National Laboratory, Oak Ridge, Tenn.

Atomic Energy Project, University of California at Los Angeles

Sandia Corporation, Sandia, N. Mex.

Hanford Operations Office, U. S. Atomic Energy Commission, Richland, Wash.

Idaho Operations Office, U. S. Atomic Energy Commission, Idaho Falls, Idaho

New York Operations Office, U. S. Atomic Energy Commission, New York, N. Y.

MEASUREMENTS OF RADIOACTIVITY OUTSIDE THE U. S.

Samples of airborne dust will be taken at approximately 70 various localities throughout the world, in addition to the 41 U. S. stations. Previous studies of this kind have shown that the average gamma ray dosage delivered to world inhabitants by all tests to date is less than the dose they have received from natural background radiation during the same period of time. All of these dosages are believed by radiologists and radiobiologists to be harmless.

Radiostrontium-90 has been demonstrated to be potentially the most hazardous of bomb products which compose airborne dust or fallout. As in the past, soils will be sampled on a world-wide basis, and samples of other materials such as milk and cheese, field crops, and human and animal bones, will be taken for analysis of their radiostrontium content. These samplings are carried out, together with radiochemical analysis, for a 2-fold purpose: 1) ascertain the world-wide distribution of radioactive fission products—particularly strontium-90—in the air, water and soils of the earth as a result of atomic tests to date; 2) to ascertain the relationship of man to his environment, particularly as regards strontium-90. These observations, when combined with studies on the biological hazards of strontium-90, have disclosed that nowhere in the world are there concentrations of this isotope remotely approaching hazard-

ous amounts. The average concentration observed in human bone is less than 1/10,000 of the concentration which might be expected to show ill effect on human beings. The highest concentrations found in any individuals are less than ten times the average.

SUMMARY

Elaborate precautions are being taken to limit significant fallout to the uninhabited danger area surrounding the Eniwetok Proving Ground.

Information on radioactivity on inhabited atolls in the Marshall Islands will be obtained rapidly and transmitted to the Task Force Headquarters.

Should there be significant fallout on an inhabited atoll, monitors will advise the inhabitants regarding basic emergency measures, and the inhabitants could be moved away from the site quickly if such action were considered necessary.

Ocean water and marine life will be analyzed for radioactivity, and measurements of radioactivity will be taken within the United States and in other parts of the world. Levels of radioactivity outside the danger area are expected to be far below those which would be hazardous to exposed persons.

May 1, [illegible]

U. S. GOVERNMENT PRINTING OFFICE: [illegible]